

US008441786B2

(12) **United States Patent**  
**Williams**

(10) **Patent No.:** **US 8,441,786 B2**  
(45) **Date of Patent:** **May 14, 2013**

(54) **ELECTRONIC CONNECTORS AND FORM  
FACTOR ADAPTERS FOR ELECTRONIC  
COMPONENTS**

(75) Inventor: **Carl D. Williams**, Colorado Springs, CO  
(US)

(73) Assignee: **Jabil Circuit, Inc.**, St. Petersburg, FL  
(US)

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 291 days.

(21) Appl. No.: **12/726,714**

(22) Filed: **Mar. 18, 2010**

(65) **Prior Publication Data**

US 2011/0069443 A1 Mar. 24, 2011

**Related U.S. Application Data**

(60) Provisional application No. 61/244,574, filed on Sep.  
22, 2009.

(51) **Int. Cl.**  
**G06F 1/16** (2006.01)  
**H05K 5/00** (2006.01)  
**H05K 7/00** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **361/679.33**; 361/760

(58) **Field of Classification**  
**Search** ..... 361/679.33–679.39, 760, 767–770;  
439/157, 247, 374  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,548,451 A \* 10/1985 Benarr et al. .... 439/85  
4,941,841 A \* 7/1990 Darden et al. .... 361/679.39

5,324,205 A \* 6/1994 Ahmad et al. .... 439/66  
RE35,915 E \* 10/1998 Hastings et al. .... 439/377  
5,886,869 A \* 3/1999 Fussell et al. .... 361/679.31  
6,038,130 A \* 3/2000 Boeck et al. .... 361/735  
6,268,977 B1 \* 7/2001 Yamada et al. .... 360/99.06  
7,053,478 B2 \* 5/2006 Roper et al. .... 257/686  
7,066,751 B2 \* 6/2006 Chen ..... 439/247  
7,137,837 B2 \* 11/2006 Chen et al. .... 439/247  
7,459,629 B2 \* 12/2008 Chen ..... 174/50  
7,548,418 B2 \* 6/2009 Martin et al. .... 361/679.37  
7,903,401 B2 \* 3/2011 Lee et al. .... 361/679.33  
2004/0214463 A1 \* 10/2004 Chen ..... 439/247  
2005/0117249 A1 \* 6/2005 Spychalla ..... 360/98.04  
2006/0044674 A1 \* 3/2006 Martin et al. .... 360/97.01  
2006/0050429 A1 \* 3/2006 Gunderson et al. .... 360/97.01  
2006/0061953 A1 \* 3/2006 Le ..... 361/684  
2006/0199409 A1 \* 9/2006 Chen et al. .... 439/247  
2008/0037211 A1 \* 2/2008 Martin et al. .... 361/685  
2008/0239650 A1 \* 10/2008 Fujie et al. .... 361/685  
2008/0239651 A1 \* 10/2008 Curnalia et al. .... 361/685  
2009/0091884 A1 \* 4/2009 Walker et al. .... 361/679.37  
2011/0069441 A1 \* 3/2011 Killen et al. .... 361/679.33

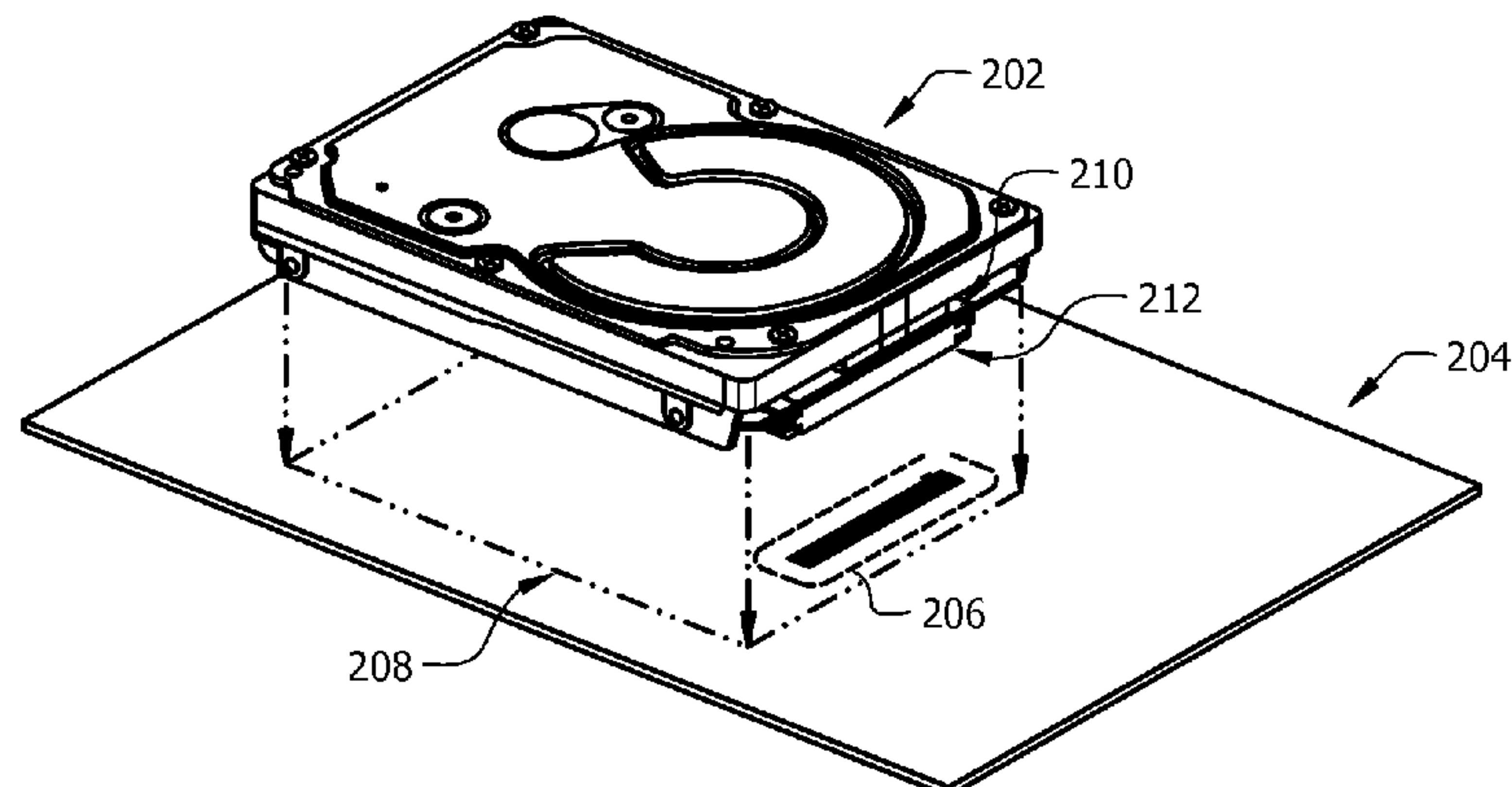
\* cited by examiner

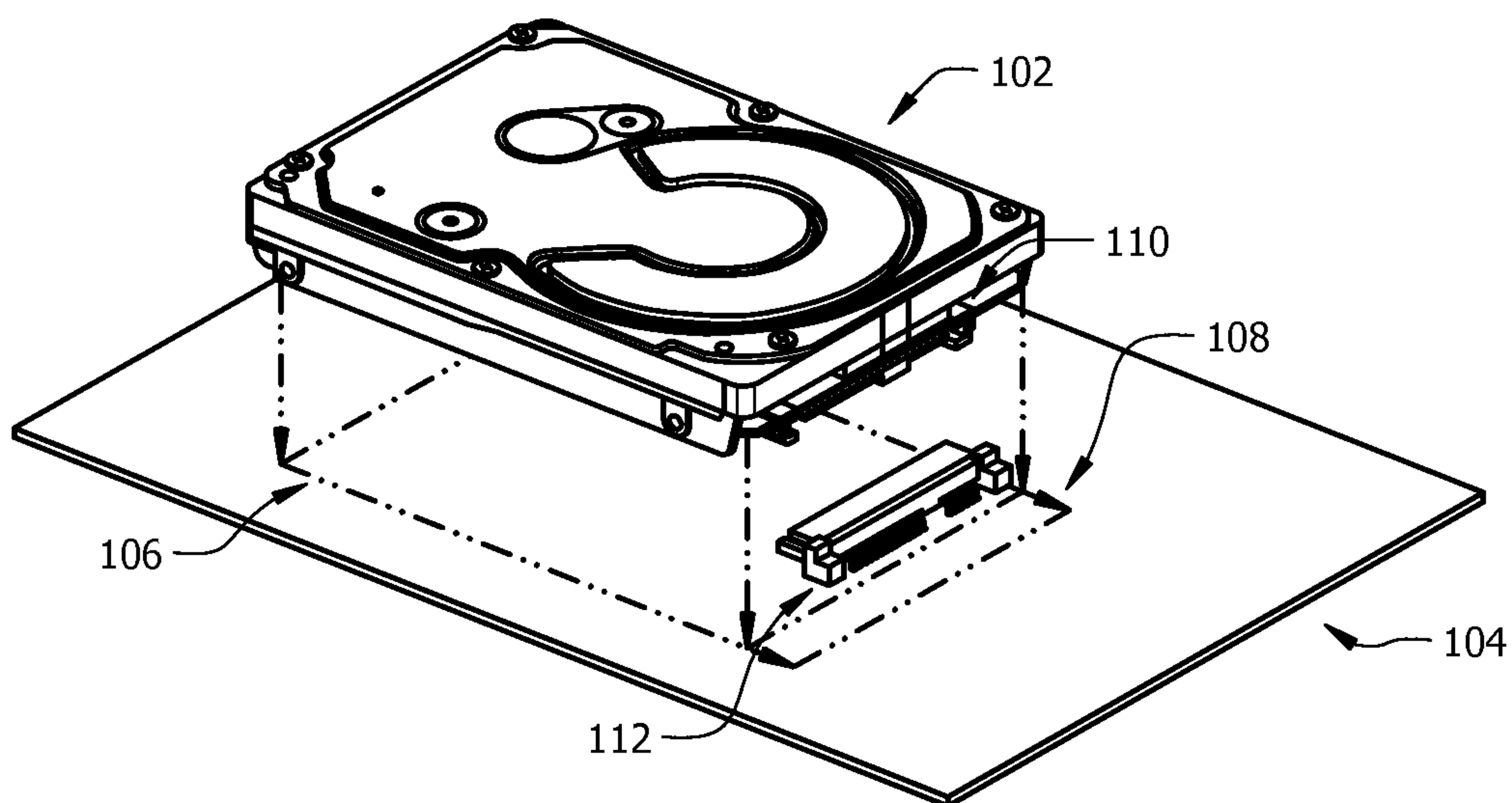
*Primary Examiner* — Adrian S Wilson

(57) **ABSTRACT**

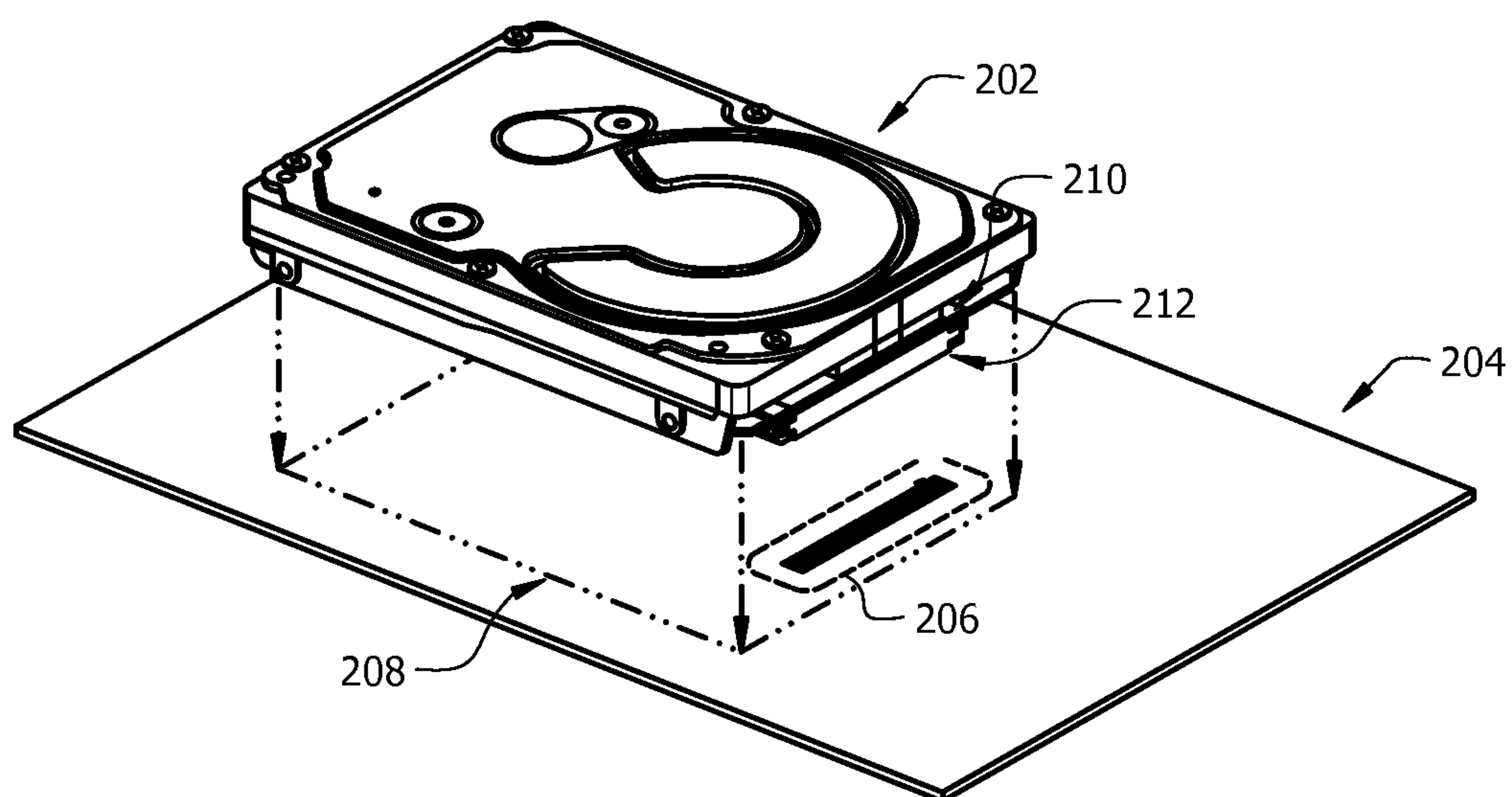
A system and method for installing a peripheral device on a printed circuit board (PCB) is provided. In the system and method, the PCB has a board connector portion and the peripheral device has a device connector portion. The method includes providing a connector adapter housing enclosing a first mating portion configured for mating with the board connector portion and a second mating portion configured for mating with the device connector portion. The method also includes engaging the second mating portion with the device connector portion to position the first mating portion to extend substantially perpendicular to the surface of the PCB. The method further includes depositing the peripheral on the PCB using a motion substantially perpendicular to the surface of the PCB, the motion engaging the board connector portion and the first mating portion.

**20 Claims, 6 Drawing Sheets**

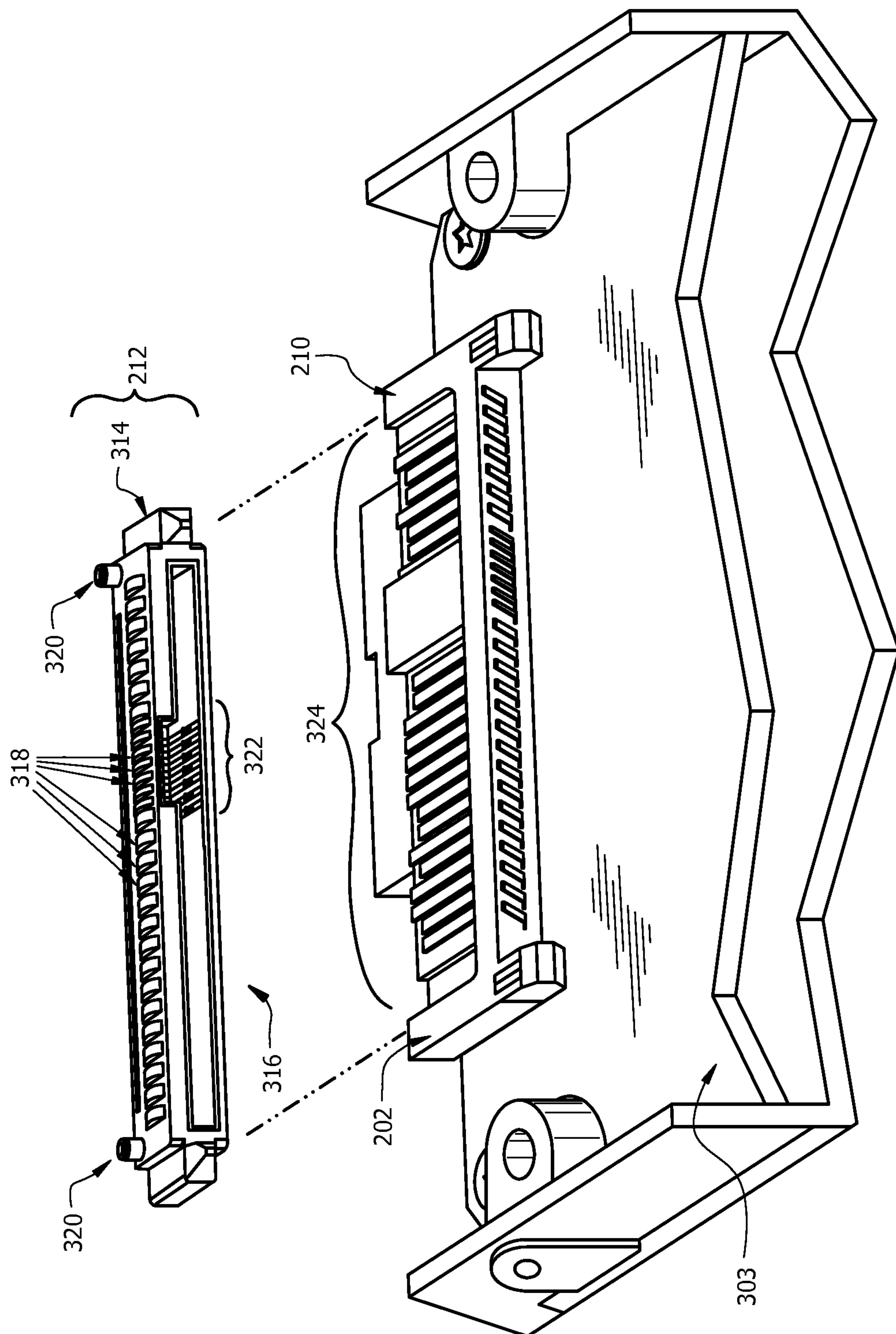




*FIG. 1*  
*(Prior Art)*



*FIG. 2*



**FIG. 3**



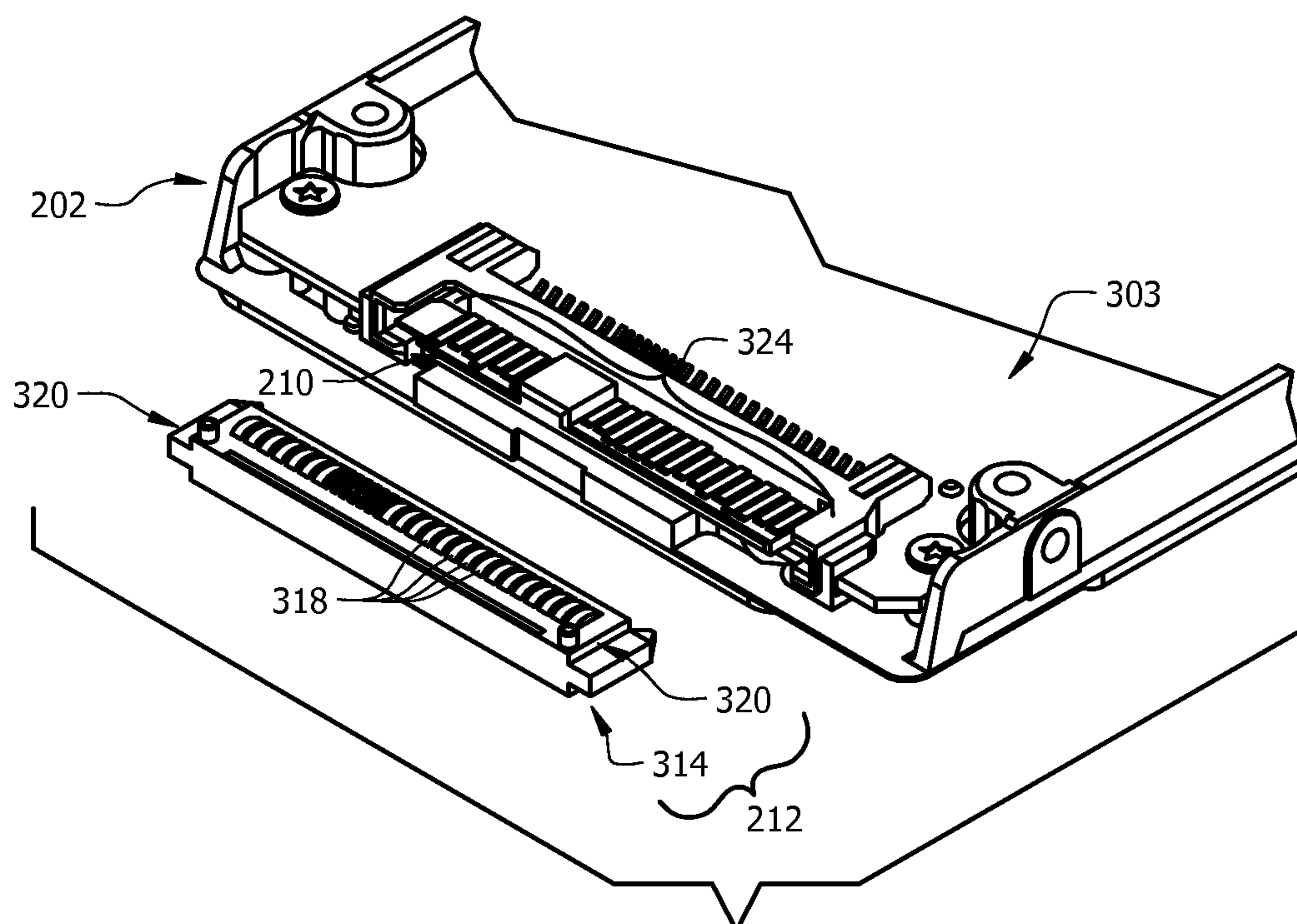


FIG. 4

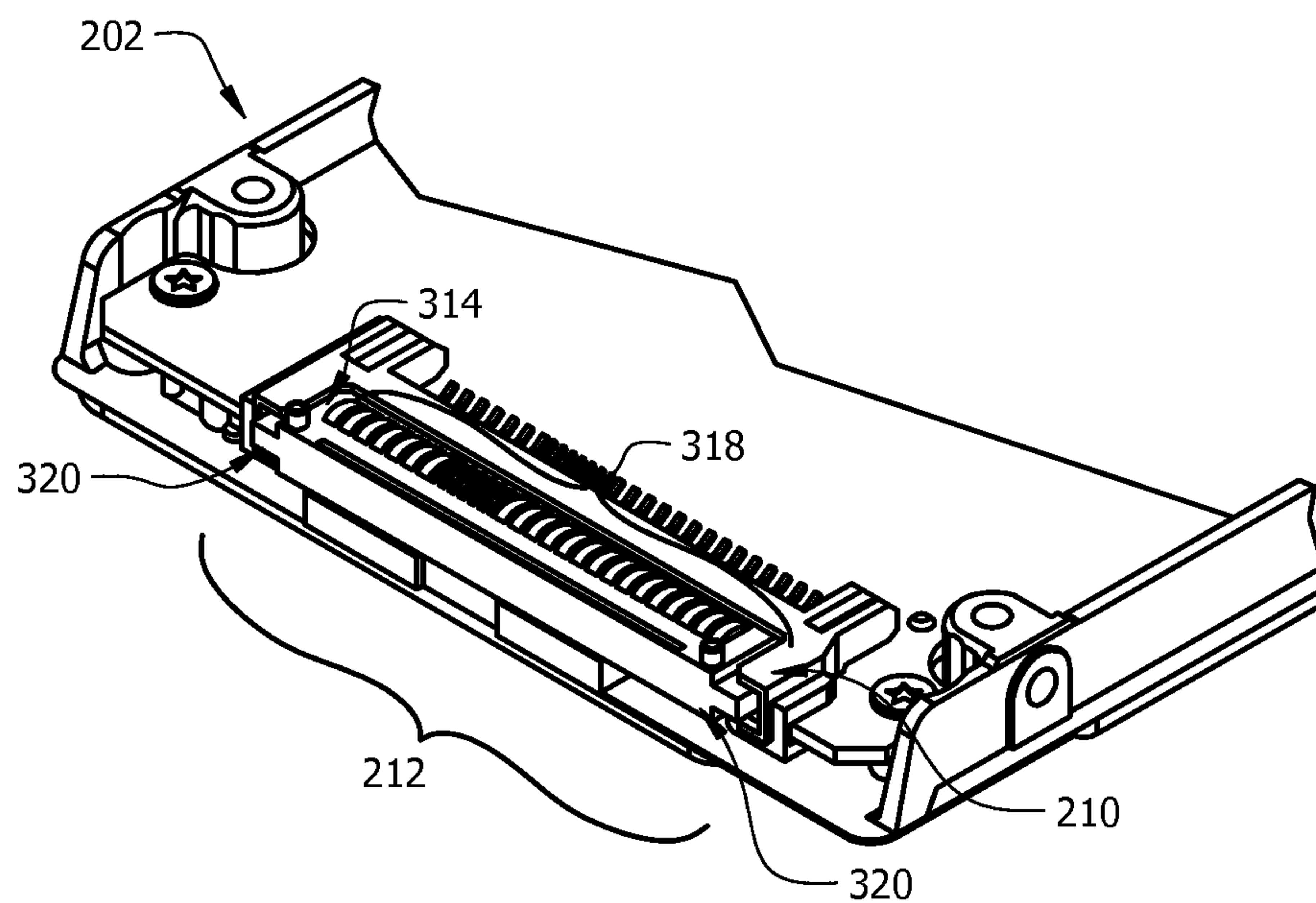


FIG. 5

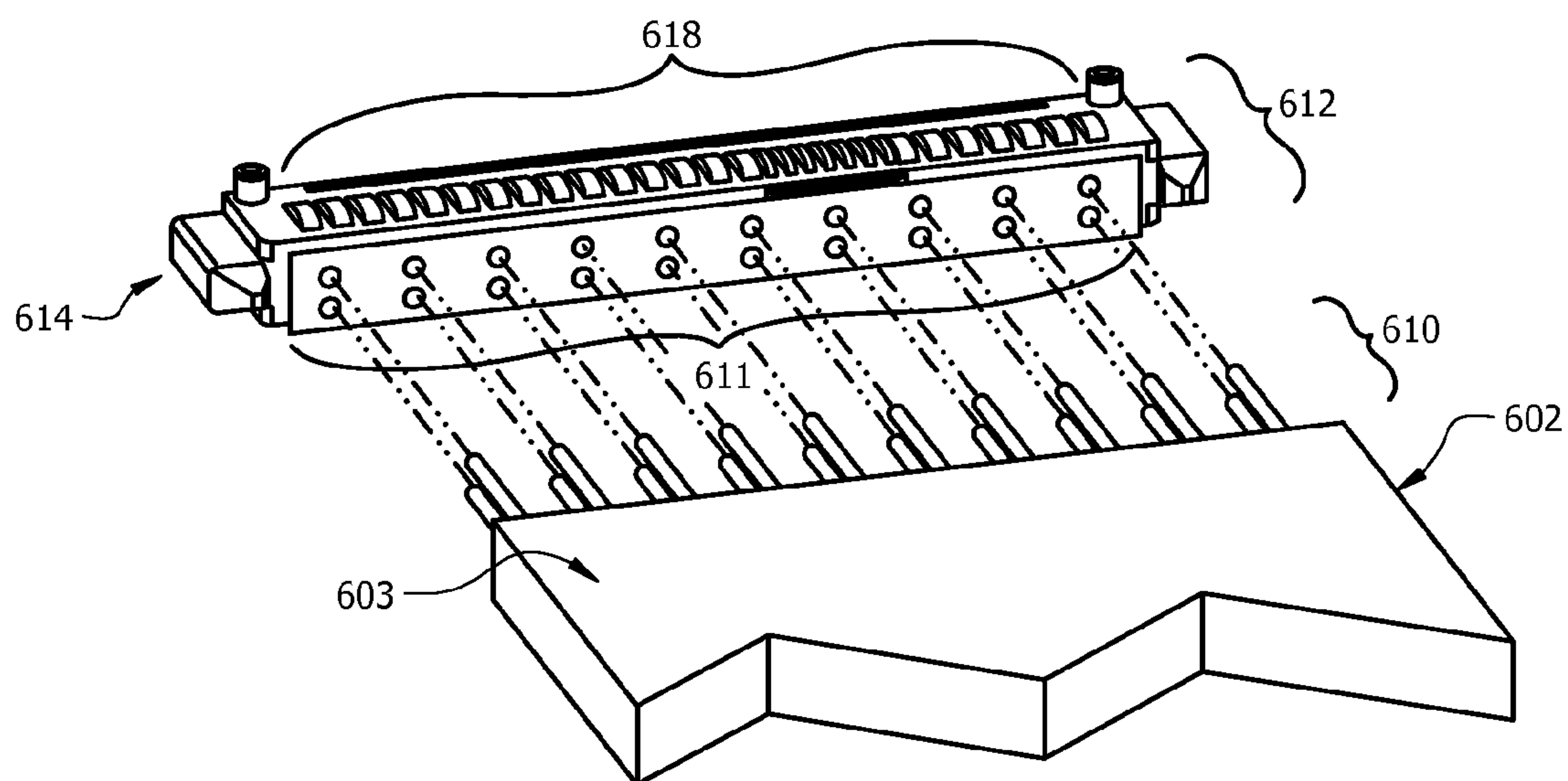


FIG. 6

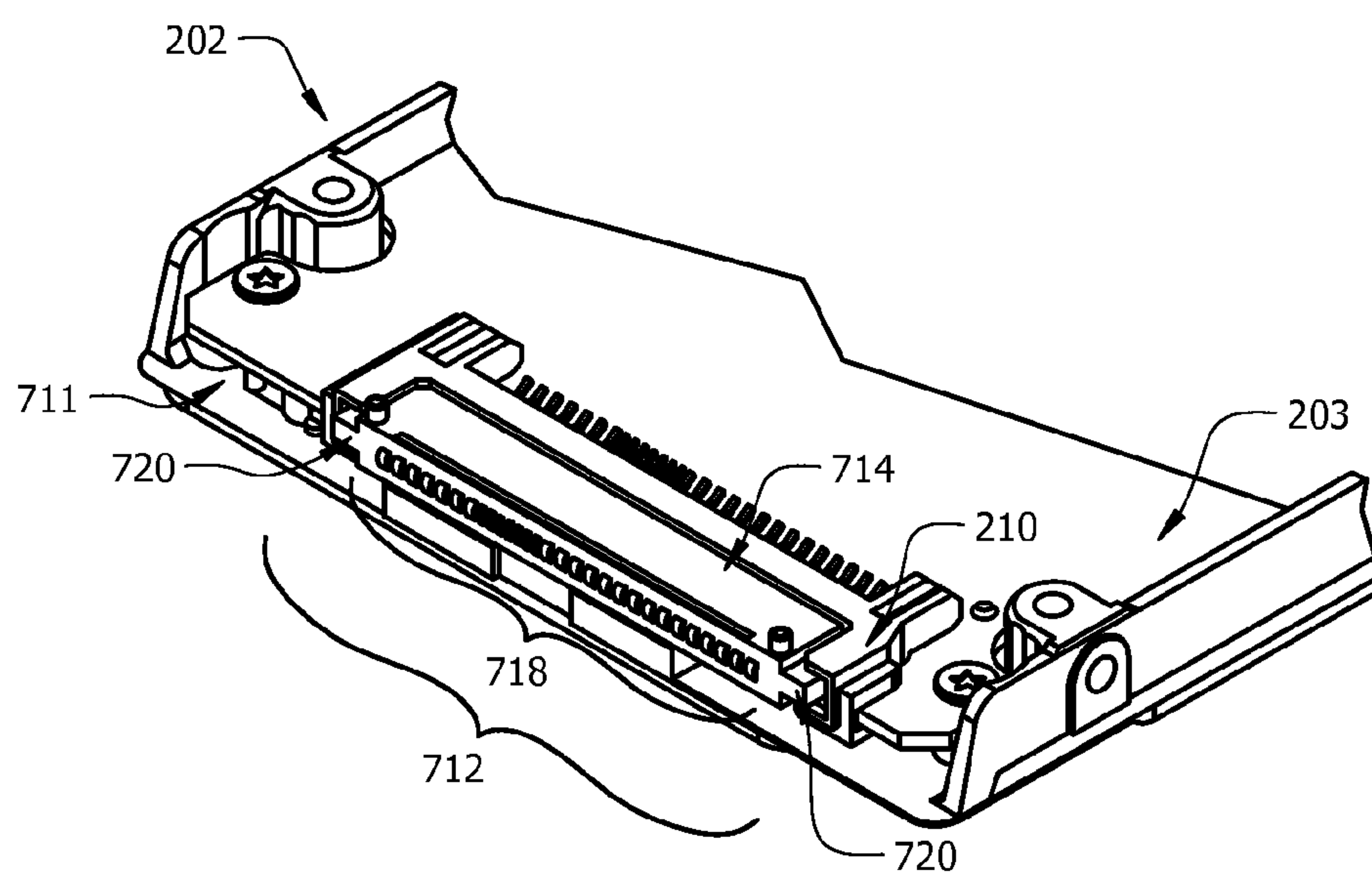


FIG. 7

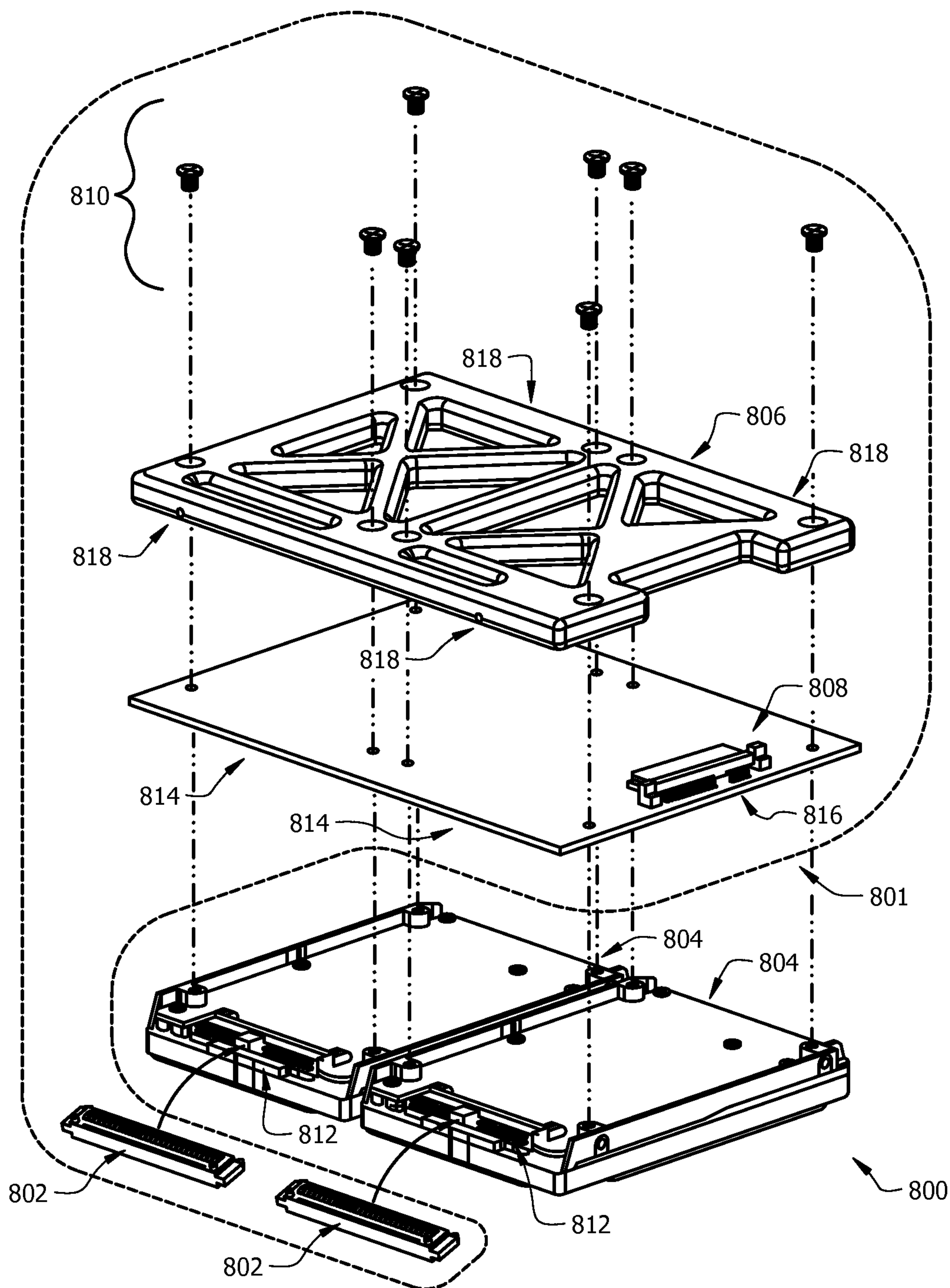


FIG. 8

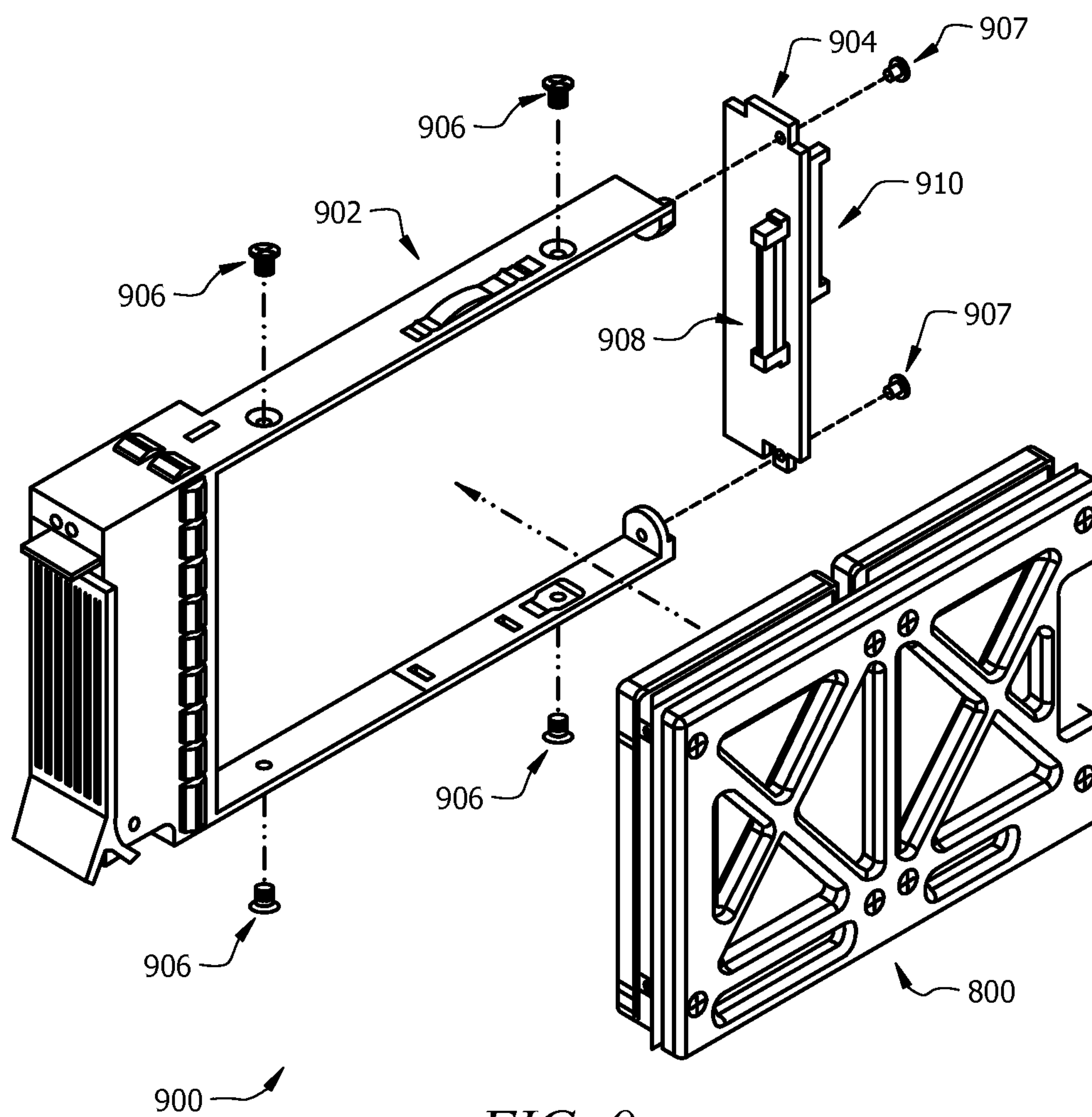


FIG. 9



1

# ELECTRONIC CONNECTORS AND FORM FACTOR ADAPTERS FOR ELECTRONIC COMPONENTS

## CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims the priority of U.S. provisional patent application Ser. No. 61/244,574 filed Sep. 22, 2009, entitled "Serial Contact or Compression Connector" and is incorporated herein in its entirety.

## FIELD OF THE INVENTION

The present invention relates to adapters, and more specifically to electronic connector adapters and form factor adapters for electronic components.

## BACKGROUND

Many conventional electronic devices consist of a main component, such as a motherboard, and additional supporting components, such as storage devices and input/output devices. In general, the supporting components for such electronic devices are connected to the main component using a receptacle-type connector assembly system. In some devices, the main and supporting components of the electronic device will each be designed with a male connector having a plurality of electrical contacts or pins within. A cable with female connectors corresponding to the male connectors is then provided to span the physical gap between the main component and the supporting component. For example, ribbon cables are commonly used in computing devices, such as handheld, laptop, and desktop computers.

As the demand for portable electronic devices has increased, the need for reducing weight and space requirements of such devices has also increased. Accordingly, in an effort to reduce the amount of space needed for the portable electronic device, many electronic device designs have been modified by eliminating the need for cables. In particular, the male connector on either the main component or the supporting component has been replaced in many devices with a female connector to allow the supporting component to be directly connected to the main component. Unfortunately, many types of electronic devices use supporting components designed and manufactured according to standardized configurations, such as data hard disc drives. As a result, electronic device designers must generally design the main component of an electronic device to accommodate connection of the standardized component. This can represent a challenge for designers, as standardized configurations are typically difficult to integrate into many types of portable device designs.

## SUMMARY

Embodiments of the invention provide electronic connector adapters and adapter systems and devices using such electronic connector adapters. In a first embodiment of the invention, a method for installing on a printed circuit board (PCB) having a board connector portion and a peripheral device having a device connector portion is provided. In the method, one of the board connector portion and the device connector portion provide a first connector extending perpendicular to a surface of the PCB and another of the board connector portion and the device connector portion provide a second connector extending parallel to the surface of the

2

PCB. The method includes providing a connector adapter housing enclosing a first mating portion for mating with the board connector portion and a second mating portion for mating with the device connector portion. The method also includes engaging one of the first and the second mating portions with the second connector to position an other of the first and the second mating portions to extend perpendicular to the surface of the PCB. The method further includes depositing the peripheral on the PCB using a motion substantially perpendicular to the surface of the PCB, the motion causing the other of the first and the second mating portions and the first connector to engage.

In a second embodiment of the invention, a method for installing a peripheral device on a printed circuit board (PCB) is provided. The PCB has a board connector portion and the peripheral device has a device connector portion, where the device connector portion extends substantially parallel to a surface of the PCB and the board connector portion extends substantially perpendicular to the surface of the PCB. The method includes providing a connector adapter housing enclosing a first mating portion configured for mating with the board connector portion and a second mating portion configured for mating with the device connector portion. The method also includes engaging the second mating portion with the device connector portion to position the first mating portion to extend substantially perpendicular to the surface of the PCB. The method further includes depositing the peripheral on the PCB using a motion substantially perpendicular to the surface of the PCB, the motion engaging the board connector portion and the first mating portion.

In a third embodiment of the invention, a system for electrically interconnecting at least one disc drive having a first dimensional footprint to an external computing environment is provided. The system includes an external printed circuit board (PCB) separate from the disc drive, the external PCB having one or more PCB electrical connection pads. The system also includes a disc drive PCB connected to a bottom surface of the disc drive and having at least one disc drive connector portion. The system further includes a connector attached to the disc drive connector portion, the connector includes a housing, at least one socket formed on a first surface of the housing for mating with the disc drive PCB connector portion, and a plurality of spring loaded contact pads formed on a second surface of the housing. In the system, the plurality of spring loaded contact pads are springingly biased against the PCB electrical connection pads when the disc drive is deposited on the external PCB such that a solderless connection is formed between the disc drive connection portion and the external PCB. Furthermore, the housing is configured to have a size and shape such that a combined dimensional footprint of the disc drive and the connector is substantially the same as the first dimensional footprint when the connector is attached to the disc drive connector portion.

In a fourth embodiment of the invention, a connector adapter is provided. The connector adapter can include a housing, a plurality of spring-loaded contact pads extending from a first surface of the housing, and at least one socket formed in a second surface of the housing. The socket includes a plurality of contact elements electrically coupled to the plurality of spring-loaded contact pads and is adapted to receive at least a portion of a device connector of an external device. In the connector adapter, the plurality of contact elements are configured to be springingly biased against the portion of the device connector inserted into the socket are further configured to electrically couple one of a plurality of electrical elements in the portion of the device connector to



3

one of the plurality of spring-loaded contact pads. Furthermore, the housing is configured to have a size and shape such that a combined dimensional footprint of the peripheral device and the housing and a dimensional footprint of the peripheral device alone are substantially the same when the portion of the device connector is inserted into the socket.

In a fifth embodiment of the invention, a storage system is provided. The system includes a mass storage device having a drive form factor, the mass storage device having a drive connector for providing an external electrical interface to the storage device when connecting to an external computing environment. The system also includes a printed circuit board (PCB), separate from the storage device, that forms part of a computing environment external to the mass storage device, the PCB having a plurality of electrical connection pads for electrically interfacing with the mass storage device. The system further includes a connector adapter attached to the drive connector, the connector adapter includes a housing, at least one socket formed on a first surface of the housing for receiving and mating with the drive connector, and a plurality of contact pads formed on a second surface of the housing. In the system, the mass storage device is removably attached to the PCB in a flat surface mounted arrangement, such that the plurality of contact pads on the connector adapter is biased against the plurality of PCB electrical connection pads to electrically interconnect the mass storage device and the PCB.

In a sixth embodiment of the invention, a system is provided for electrically interconnecting at least one storage device having a first dimensional footprint to an external computing environment. The system includes an external printed circuit board (PCB) separate from the storage device, the external PCB having one or more PCB electrical connection elements. The system further includes a storage device PCB connected to a bottom surface of the storage device and having at least one storage device connector portion. The system also includes a connector attached to the storage device connector portion, the connector includes a housing, at least one socket formed on a first surface of the housing for mating with one of the storage device PCB connector portion and the PCB electrical connection elements, and a plurality of spring loaded contact pads formed on a second surface of the housing. In the system, the plurality of spring loaded contact pads are springingly biased against an other of the storage device PCB connector portion and the PCB electrical connection elements when the storage device is deposited on the external PCB such that a solderless connection is formed between the storage device connection portion and the external PCB, and the housing is configured to have a size and shape such that a combined dimensional footprint of the storage device and the connector is substantially the same as the first dimensional footprint when the connector is attached to the storage device connector portion.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates conventional flat surface mounting of a hard disc drive on a motherboard.

FIG. 2 conceptually illustrates flat surface mounting of a hard disc drive on a motherboard using an electrical connector adapter in accordance with an embodiment of the invention.

FIG. 3 shows a perspective view of the electrical connector adapter and the drive FIG. 2, prior to connection.

FIG. 4 shows a perspective view of the electrical connector adapter and the drive FIG. 2, prior to connection.

4

FIG. 5 shows a perspective view of the electrical connector adapter and the drive FIG. 2, after connection.

FIG. 6 shows a perspective view of another exemplary electrical connector adapter and a device with pin-type connectors, prior to connecting, in accordance with an embodiment of the invention.

FIG. 7 shows a perspective view of an alternate connector adapter connected to a disc drive in accordance with an embodiment of the invention.

FIG. 8 is an exploded view of a hard disc drive device including a factor adapter having at least one electrical connector adapter in accordance with an embodiment of the invention.

FIG. 9 is an exploded view of a server hard disc drive carrier using the assembled hard disc drive device 800 of FIG. 8.

#### DETAILED DESCRIPTION

The present invention is described with reference to the attached figures, wherein like reference numerals are used throughout the figures to designate similar or equivalent elements. The figures are not drawn to scale and they are provided merely to illustrate the instant invention. Several aspects of the invention are described below with reference to example applications for illustration. It should be understood that numerous specific details, relationships, and methods are set forth to provide a full understanding of the invention. One having ordinary skill in the relevant art, however, will readily recognize that the invention can be practiced without one or more of the specific details or with other methods. In other instances, well-known structures or operations are not shown in detail to avoid obscuring the invention. The present invention is not limited by the illustrated ordering of acts or events, as some acts may occur in different orders and/or concurrently with other acts or events. Furthermore, not all illustrated acts or events are required to implement a methodology in accordance with the present invention.

As described above, one of the main challenges in designing portable devices is accommodating components that have standardized configurations, particularly during assembly. For example, a conventional hard disc drive is substantially flat (i.e., its side surfaces are substantially smaller than its top and bottom surfaces), but the electrical connectors in such hard disc drives are generally located along side surfaces. Accordingly, flat surface mounting of such hard disc drive devices on, for example, a motherboard is non-trivial. This is illustrated in FIG. 1. FIG. 1 illustrates conventional flat surface mounting of a hard disc drive 102 on motherboard 104. As shown in FIG. 1, flat surface mounting of hard disc drive 102 requires defining an initial placement area 106 on the motherboard 104. This configuration also requires defining a motion area 108 on the motherboard 104 to allow motion of hard disc drive 102 in a direction parallel to the surface of motherboard 104. That is, an area in addition to area 106, that defines the travel area of the end of disc drive 102 with a drive connector 110 along the surface of motherboard 104 to engage a motherboard connector 112 on the motherboard 104.

This conventional configuration suffers from several problems. First, if the hard disc drive 102 is added after the motherboard 104 is placed in a housing, additional space in at least the housing must be provided to accommodate the lateral motion of the hard disc drive 102 during assembly. Second, since the hard disc drive 102 must be moved over the surface of motherboard 104, areas 106 and 108 must be substantially devoid of components that could be damaged



## 5

during motion of the hard disc drive **102**. Accordingly, at least a portion of areas **106** and **108** may be unavailable for some types of components. Such components can be relocated to other portions of motherboard **104**, but this potentially increases the size of the resulting electronic device. Third, connectors, such as connector **110** or **112**, typically include pins or other protruding portions, as described above, which are susceptible to damage due to mishandling. Finally, the force typically required to insert connector **110** into connector **112** is significant. Accordingly, if the hard disc drive **102** is not properly positioned over motherboard **104**, the applied force can damage connector **110** or connector **112**, or even damage hard disc drive **102** or motherboard **104**.

To overcome the various limitations of conventional component mounting configurations in electronic devices, embodiments of the invention provide an electrical connector adapter, with a minimum footprint, for surface mounting electronic device components. In particular, an adapter in accordance with an embodiment of the invention is configured have a first surface with at least one socket for receiving a male or female connector of an existing component and second surface with a plurality of spring loaded pads for contacting a plurality of pads on another component, such as on a surface of a motherboard. This configuration is conceptually illustrated with respect to FIG. 2.

Although the various embodiments of the invention will be principally illustrated with respect to the mounting of hard disc drive components, the invention is not limited in this regard. Rather, the various embodiments of the invention can be used with any type of components for an electrical device, including, but not limited to input/output devices, memory modules, and other peripheral devices.

FIG. 2 conceptually illustrates surface mounting of a hard disc drive on a motherboard using an electrical connector adapter in accordance with an embodiment of the invention. Similar to the configuration in FIG. 1, the configuration in FIG. 2 also shows a hard disc drive **202**, a mass storage device, with a standardized hard disc drive connector **210** and a motherboard **204**. However, the configuration of FIG. 2 varies from the configuration of FIG. 1 in several ways. First, rather than providing a motherboard connector, as in FIG. 1, the motherboard **204** includes a plurality of pads **206** for receiving signals from hard disc drive **202**. This simplifies board design and manufacturing complexity. Second, the hard disc drive connector **210** is fitted with an electrical connector adapter **212**. The electrical connector adapter **212** includes a socket for receiving the electrical connector **210** and a plurality of spring-loaded pads (not shown) for contacting pads **206**.

As a result of the configuration of FIG. 2, several advantages are provided. First, no additional lateral space must be provided to accommodate motion of the hard disc drive **202**. As shown in FIG. 2, to electrically connect hard disc drive **202** to motherboard **204**, the hard disc drive **202** is directly positioned on motherboard **204** such that the spring-loaded pads on adapter **212** line up with pads **206**. This permits, among other things, a pick and place assembly process to be used for manufacturing, which can significantly reduce costs. Second, the hard disc drive **202** need not be moved over the surface of motherboard **204** during installation. As a result, an area **208** beneath hard disc drive **202** can be used to place some components on motherboard **204** without risk of damaging them. Therefore, space requirements can be reduced, resulting in potentially smaller electronic devices. Third, since adapter **212** effectively eliminates exposed protruding connector components, such as those in connector **210**, the likelihood of these connector components being damaged during installa-

## 6

tion of the hard disc drive **202** is minimized. Finally, since no force is required to connect pads **206** and the spring loaded pads on adapter **212** (other than the force required to position hard disc drive **202**), the likelihood of damaging hard disc drive **202** or mother board **204** during assembly is reduced or eliminated as well.

Electrical connector adapter **212** will now be described in greater detail below with respect to FIGS. 3, 4, and 5. FIGS. 3 and 4 show perspective views of the exemplary electrical connector adapter **210** and drive **202** in FIG. 2, prior to connection. FIG. 5 shows another perspective view of the arrangement in FIGS. 3 and 4, after connecting adapter **212** and drive **202**. As shown in FIGS. 3-5, adapter **212** comprises a housing **314**, at least one socket **316**, and a plurality of spring-loaded contact pads **318**. Further, FIGS. 3-5 show the bottom side of disc drive **202** that normally faces the motherboard.

As used herein with respect to a contact pad or other electrically conductive element, the term “spring-loaded” means that the electrically conductive element includes or is combined with at least one elastically deformable portion. This elastically deformable portion is configured to cause a change in the position or configuration of the contacting portion of the electrically conductive element when force is applied against the electrically conductive elements. For example, in one embodiment of the invention, the plurality of spring-loaded contact pads **318** can comprise a series of leaf-type springs constructed from an electrically conductive composition. However, the invention is not limited in this regard and other types of configurations can be used to provide spring-loaded contact pads.

The configuration in FIGS. 3-5 is effectively a right angle adapter. That is, when an electrical connector **210** of drive **202** is completely inserted into socket **316**, the plurality of pads **318** extend in a direction substantially perpendicular to a bottom surface **303** of drive **202**, as shown in FIGS. 3-5. As a result, drive **202** can be positioned on a motherboard over pads formed thereon, as described above with respect to FIG. 2.

In the various embodiments of the invention, the housing, socket, and pads in an adapter can be configured to provide any shape or to have any dimensions. However, in some embodiments of the invention, the shape and size of the adapter can be selected such that a combined dimensional footprint of the adapter and associated component is substantially the same as the dimensional footprint of the associated component alone. For example, in the embodiment illustrated in FIGS. 3 and 4, the shape and dimensions of housing **314**, socket **316**, and pads **318** for adapter **212** are selected such that when a drive connector **210** of drive **202** is completely inserted into socket **306**, little or no portions of housing **314** and pads **318** extending beyond a volume defined by the outermost dimensions of drive **202**. Consequently, the dimensional footprint of drive **202** is substantially unchanged after the addition of connector housing.

The term “dimensional footprint”, as used herein, refers to the footprint of a device in terms of area or volume. The term “substantially” as used herein with respect to a quantity, means that the quantity can vary by 10% with respect to a reference quantity.

In some embodiments of the invention, adapter **212** can be configured to include one or more features to facilitate mounting of hard disc drive **202** (including adapter **212**) in an electronic device. For example, as shown in FIG. 3-5, one or more guide projections **320** can extend from housing **314**. In the embodiment illustrated in FIGS. 3-5, the guide projections **320** comprise posts extending substantially in the same



direction as pads **318**. The guide projections **320** can be configured to mate with openings or other features in an electronic device to facilitate alignment of pads **318** with corresponding pads in the electronic device.

In the various embodiments of the invention, a socket of an electrical connector adapter can be configured in a variety of ways. For example, as shown in FIG. 3, socket **316** is a female microstrip connector configured for receiving connector **210**, comprising a male microstrip connector. In addition to being dimensioned to receive the male microstrip connector, socket **316** can include one or more spring-loaded contact elements **322**. The contact elements **322** are configured to electrically couple each of microstrip elements **324** of connector **210** to one of pads **318**. In some embodiments of the invention, the contact elements **322** are configured to be resiliently biased against the microstrip elements **324**. In such embodiments of the invention, the contact elements **322** can also provide enough force to retain connector **210** in socket **316** without the need for additional fasteners. However, the invention is not limited in this regard and a fastening system can be provided to retain connector **210** in socket **316**. For example, one or more fasteners can be used to attach adapter **212** to drive **202**.

In the embodiment illustrated in FIGS. 3-5, adapter **212** is illustrated as including a socket for engaging connector **210** of drive **202** and pads **318** for contacting pads **206** on motherboard **204**. However, the various embodiments of the invention are not limited in this regard. In some embodiments of the invention, adapter **212** can be configured to provide a reverse configuration. That is, an adapter in accordance with an embodiment of the invention can instead be configured to include a socket for engaging a connector on motherboard and pads for contacting pads of a hard disc drive or other component to be mounted on the motherboard.

Further, although FIG. 3 shows only a male micro strip connector configuration, the various embodiments of the invention are not limited in this regard. Rather, the various embodiments of the invention can be used to provide electrical connector adapters for any other type of connector configuration, including male connectors, female connectors, or any combination thereof. For example, in addition to male or female microstrip connectors, the various embodiments of the invention are equally applicable to pin-type connectors. For example, FIG. 6 shows a perspective view of another exemplary electrical connector adapter **612** and a device **602** with pin-type connectors **610**, prior to connecting, in accordance with an embodiment of the invention.

Similar to the adapter in FIGS. 3-5, adapter **612** also comprises a housing **614**, a plurality of sockets **616**, and a plurality of spring-loaded contact pads **618**. The configuration in FIG. 6 is also effectively a right angle adapter. That is, when pins **610** of device **602** are completely inserted into sockets **616**, the plurality of pads **618** extend in a direction perpendicular to a bottom surface **603** of device **602**, as shown in FIG. 5. As a result, device **602** can be positioned on a motherboard over pads formed thereon, as described above with respect to FIG. 2-5.

In the various embodiments of the invention, the sockets **616** can be configured in a variety of ways for contacting and retaining pin-type connectors. For example, in addition to being dimensioned to receive pin-type connector **610**, sockets **616** can include one or more spring-loaded contact elements (not shown) within housing **614**. These contact elements are configured to electrically couple each of pin-type connectors **610** to one of pads **618**. In some embodiments of the invention, such contact elements can be configured to be springingly biased against the pin-type connectors **610**. In such

embodiments of the invention, these contact elements can also provide enough force to retain pin-type connectors **610** in sockets **616** without the need for additional fasteners. However, the invention is not limited in this regard and a fastening system can be provided to pin-type connectors **610** in sockets **616**. For example, one or more fasteners can be used to attach adapter **612** to device **602**.

Although the exemplary embodiments described above provide right angle adapters, the various embodiments of the invention are not limited in this regard. In other embodiments of the invention, the plurality of spring-loaded contact pads can be configured to extend in other directions. This is illustrated in FIG. 7. FIG. 7 shows a perspective view of an alternate connector adapter **712** connected to drive **202**. Similar to the configuration in FIGS. 3-5, the configuration in FIG. 7 also includes an adapter **712** coupled to a hard disc drive connector **210** of a 2.5 serial ATA hard disc drive **202**. The adapter **712** also comprises a housing **714**, at least one socket (not shown), and a plurality of spring-loaded contact pads **718**. In the configuration shown in FIG. 7, the contact pads **718** extend in a direction perpendicular to an edge **711** on which connector **210** is located. Such a configuration allows hard disc drive **202** to be mounted in a substantially vertical orientation as opposed to the substantially horizontal orientation illustrated in FIG. 2.

As described above, using electrical connector adapters in accordance with the various embodiments of the invention provides several advantages with respect to mounting components in electronic devices. However, electrical connector adapters in accordance with the various embodiments of the invention can also be used to provide form factor adapters for some types of applications.

For example, many types of servers typically utilize removable drive storage systems. In general, a hard disc drive for such a server is generally mounted in a carrier that can be removeably installed in a server system. Over time, the increasing storage needs of the server are typically met by adding additional drives, each mounted individually in a carrier. However, such a configuration typically faces two problems over time. First, such server systems typically have a finite number of slots for adding additional drive carriers. Accordingly, a new server system or at least a significant hardware and/or software upgrade is needed to add additional drive carriers. Second, as hard disc drive technologies evolve over time, they are generally applied to hard disc drives with smaller form factors. Accordingly, the storage capacity of a server having drive carriers configured for older form factors is effectively limited by the extent such advanced hard disc drive technologies have been applied to compatible hard disc drives.

However, hard disc drive designs generally conform to particular form factor configurations. In particular, hard disc drive form factors have been generally designed such that the length and width of a hard disc drive of a particular form factor are equal to the width and  $\frac{1}{2}$  the length, respectively, of a hard disc drive of a preceding form factor. Furthermore, the height of a hard disc drive of a particular form factor is generally less than or equal to the height of a hard disc drive of a preceding form factor. Consequently, it is typically possible to arrange two or more hard disc drives of a particular form factor in volume previously occupied by a hard disc drive of a preceding form factor.

One problem with many conventional form factor adapters for disc drive is that the connection between the larger form factor disc drive interface and the smaller form factor disc drive must typically be accomplished via the use of ribbon cable-type connectors. However, when attempting to use two



or more smaller form factor disc drives in the space of a larger form factor disc drive, it is difficult to route such ribbon-type connectors in the space available. Accordingly, the volume required by such smaller form factor disc drives is effective larger than that of the larger form factor disc drive. Furthermore, the use of ribbon-type connectors is often problematic for maintenance purposes. In particular, removal of a disc drive requires not only that the disc drive be disengaged from the housing, but the manipulation of the ribbon-type cable to electrically disconnect such disc drives. Such manipulations, if occurring frequently, can result in degrading of the ribbon-type connection, requiring replacement or resulting in access errors.

Accordingly, based on the relationship between the different form factors, a form factor adapter using electrical connector adapters in accordance with an embodiment of the invention can be provided. The use of such adapters eliminates the various difficulties associated with ribbon-type connectors, improving reliability of the devices and facilitating maintenance of the systems that the disc drives are attached to. This is shown below with respect to FIG. 8.

FIG. 8 is an exploded view of a hard disc drive device including a factor adapter system **801** having at least one electrical connector adapter **802** in accordance with an embodiment of the invention. As shown in FIG. 8, a form factor adapter system **801** is provided for mounting two or more hard disc drives **804** in a space of a larger form factor hard disc drive. The form factor adapter includes a supporting frame **806**, a circuit board **808**, a plurality of fasteners **810**, and electrical connector adapters **802**.

The hard disc drive device **800** is assembled for use as follows. First, electrical connector adapters **802** are inserted into connectors **812** of hard disc drives **804**, as described above with respect to FIGS. 2-5. In the embodiment illustrated in FIG. 8, connector adapters **802** are substantially similar to the connector adapter described above with respect to FIGS. 2-5. The hard disc drives **804** can then be positioned on circuit board **808**, such that contacts on each of connector adapters **802** is aligned with contact pads **814** on a surface of board **808**. Board **800** can also have a connector **816** and components, circuitry, and/or software for accessing drives **804** via connector **816**. Board **808** and hard disc drives **804** can then be positioned on frame **806** and fastened together using fasteners **810**. However, the invention is not limited to the assembly process described above. For example, in some embodiments of the invention, board **808** and frame **806** can be fastened together first. Additionally, each of hard disc drives **804** can be fastened separately to board **808** and frame **806**.

In the exemplary embodiment illustrated in FIG. 8, the resulting configuration provides a hard disc drive device that is compatible with a form factor of a hard disc drive of a larger form factor. As used herein with respect to form factors, the term "compatible" means that the resulting hard disc drive device mechanically and electrically matches the hard disc drive being replaced. For example, as shown in FIG. 8, hard disc drive device **800** electrically matches a larger hard disc drive being replaced. In particular, board **808** can be configured to have a connector **816** having a same connector type as that of the larger hard disc drive being replaced. Furthermore, connector **816** can be positioned in assembled drive device **800** to match a location of such a connector in the larger hard disc drive being replaced. Hard disc drive **800** also mechanically matches the larger hard disc drive being replaced. In particular, one or more mounting elements **818** can be provided at locations in the frame **806** corresponding to the location of mounting elements in the larger hard disc drive.

For example, threaded holes can be provided in frame **806** at the same locations in which threaded holes would be provided in a hard disc drive of a larger form factor. Accordingly, the resulting hard disc drive device **800** can be mechanically attached or installed in an electronic device without any modification of the electronic device. This is illustrated with respect to FIG. 9.

FIG. 9 is an exploded view of a server hard disc drive carrier **900** using the assembled hard disc drive device **800** of FIG. 8. As shown in FIG. 9, a server drive carrier **900** includes a carrier frame **902** designed for a larger form factor hard disc drive device, a paddle board **904**, a plurality of carrier frame fasteners **906**, and a plurality of paddle board fasteners **907**. Paddle board **904** can include a first paddle connector **908** for connecting paddle board **904** to the larger hard disc drive device. Paddle board **904** can also include a second paddle connector **910** for connecting paddle board **904** to a server (not shown).

Carrier **900**, including hard disc drive device **800**, can be assembled as follows. First, hard disc drive device **800** can be placed within carrier frame **902** and fixed in place via carrier fasteners **906**. Afterwards, paddle board **904** can be attached to hard disc drive device **800** and secured in place using paddle board fasteners **907**. In the embodiment illustrated in FIG. 9, the paddle fasteners attach paddle board **904** to the carrier frame **902**. However, the various embodiments of the invention are not limited in this regard and other types of drive carriers can be used.

The configuration in FIG. 9 provides several advantages. First, it allows older, slower, larger, and lower capacity hard disc drives to be replaced with two or more newer, faster, smaller, and higher capacity hard disc drives. That is, since the configuration of hard disc drive device **800** is compatible with the form factor of the larger hard disc drive device frame **902** was originally design for, no modification of frame **902** or paddle board **904** is needed. Accordingly, a performance enhancement can be obtained. Second, the configuration in FIG. 9 provides a configuration than can be easily maintained. As described above with respect to FIG. 8, each of the drives in hard disc drive device **800** is attached to the supporting frame of device **800** and is surface mounted using an electrical connector in accordance with an embodiment of the invention. Therefore, since the hard disc drives are not directly attached to carrier frame **902** and no lateral motion of the hard disc drives is necessary for their removal, the drive can be removed without the need to significantly disassemble carrier **900**. For example, to remove one of the hard disc drives in device **800**, only the fasteners mechanically coupling a hard disc drive to device **800** need be removed. The hard disc drive can then be lifted out of carrier **900**. A new drive can then be installed by providing an electrical connector adapter for the hard disc drive and placing and fastening the hard disc drive back to device **800**.

While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not limitation. Numerous changes to the disclosed embodiments can be made in accordance with the disclosure herein without departing from the spirit or scope of the invention. For example, although a hard disc drive (**202**, **804**) has been shown in the various embodiments, use other types of mass storage devices, such as solid-state drives, with similar form factors, or standardized interfaces requirements are contemplated to be within the scope of this invention. Thus, the breadth and scope of the present invention should not be limited by any of the above described embodiments. Rather,



## 11

the scope of the invention should be defined in accordance with the following claims and their equivalents.

Although the invention has been illustrated and described with respect to one or more implementations, equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In addition, while a particular feature of the invention may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. Furthermore, to the extent that the terms “including”, “includes”, “having”, “has”, “with”, or variants thereof are used in either the detailed description and/or the claims, such terms are intended to be inclusive in a manner similar to the term “comprising.”

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

What is claimed is:

1. A method for installing a peripheral device on a printed circuit board (PCB) having a board connector portion, the peripheral device having a device connector portion, one of said board connector portion and said device connector portion providing a first connector extending perpendicular to a surface of said PCB and another of said board connector portion and said device connector portion providing a second connector extending parallel to said surface of said PCB, the method comprising:

providing a connector adapter housing enclosing a first mating portion for mating with said board connector portion and a second mating portion for mating with said device connector portion;

engaging one of said first and said second mating portions with said second connector to position an other of said first and said second mating portions to extend perpendicular to said surface of said PCB; and

depositing said peripheral device on said PCB using a motion substantially perpendicular to said surface of said PCB, said motion causing said other of said first and said second mating portions and said first connector to engage.

2. The method of claim 1, wherein said providing comprises selecting said connector adapter housing to include at least one guide projection for engaging a guide opening in said PCB during said depositing.

3. The method of claim 1, wherein said providing comprises selecting said connector adapter housing to have a size and shape such that a combined dimensional footprint of said peripheral device and said connector adapter housing is substantially the same as a dimensional footprint of said peripheral device alone when said connector adapter housing engages said device connector portion.

4. The method of claim 1, wherein said providing comprises selecting said one of said first and said second mating

## 12

portions to comprise a plurality of spring-loaded contact elements configured to apply a force against said second connector, such that said connector adapter housing is retained on said second connector portion exclusive of fasteners.

5. A method for installing a peripheral device on a printed circuit board (PCB), said PCB having a board connector portion and said peripheral device having a device connector portion, said device connector portion extending substantially parallel to a surface of said PCB and said board connector portion extending substantially perpendicular to said surface of said PCB, the method comprising:

providing a connector adapter housing enclosing a first mating portion configured for mating with said board connector portion and a second mating portion configured for mating with said device connector portion;

engaging said second mating portion with said device connector portion to position said first mating portion to extend substantially perpendicular to said surface of said PCB;

depositing said peripheral device on said PCB using a motion substantially perpendicular to said surface of said PCB, said motion engaging said board connector portion and said first mating portion.

6. The method of claim 5, wherein said providing comprises selecting said connector adapter housing to include at least one guide projection for engaging a guide opening in said PCB during said depositing.

7. The method of claim 5, wherein said providing comprises selecting said connector adapter housing to have a size and shape such that a combined dimensional footprint of said peripheral device and said connector adapter housing is substantially the same as a dimensional footprint of said peripheral device alone when said connector adapter housing engages said device connector portion.

8. The method of claim 5, wherein said providing comprises selecting said first mating portion to comprise a plurality of spring-loaded contact pads.

9. The method of claim 5, wherein said providing comprises selecting said second mating portion to comprise a plurality of spring-loaded contact elements configured to apply a force against said device connector portion, such that said connector adapter housing is retained on said device connector portion exclusive of fasteners.

10. A system for electrically interconnecting at least one disc drive having a first dimensional footprint to an external computing environment, comprising:

an external printed circuit board (PCB) separate from the disc drive, the external PCB having one or more PCB electrical connection pads;

a disc drive PCB connected to a bottom surface of the disc drive and having at least one disc drive connector portion; and

a connector attached to said disc drive connector portion, the connector comprising a housing, at least one socket formed on a first surface of said housing for mating with said disc drive PCB connector portion, and a plurality of spring-loaded contact pads formed on a second surface of said housing, and

wherein said plurality of spring-loaded contact pads are springingly biased against said PCB electrical connection pads when the disc drive is deposited on the external PCB such that a solderless connection is formed between the disc drive connection portion and the external PCB, and said housing is configured to have a size and shape such that a combined dimensional footprint of said disc drive and said connector is substantially the



## 13

same as said first dimensional footprint when said connector is attached to said disc drive connector portion.

11. The system of claim 10, wherein said socket comprises a plurality of spring-loaded contact elements configured to apply a force against said disc drive connector portion such that said connector is retained on said disc drive connector portion exclusive of fasteners.

12. The system of claim 10, wherein said first surface of said housing is substantially perpendicular to said second surface of said housing.

13. The system of claim 10, wherein said connector further comprises at least one connector guide feature, and said external PCB comprises at least one PCB guide feature configured for engaging said connector guide feature when the disc drive is deposited on the external PCB when said plurality of spring-loaded contact pads and said PCB electrical connection pads are in contact.

14. The system of claim 10, further comprising:

a carrier for supporting another disc drive having a second dimensional footprint greater than said first dimensional footprint; and

a supporting frame for mounting said external PCB, said at least one disc drive, and said connector in said carrier, wherein a combined dimensional footprint of said external PCB, said at least one disc drive, and said connector is less than or equal to said second dimensional footprint.

15. A connector adapter for a peripheral device, comprising:

a housing;

a plurality of spring-loaded contact pads extending from a first surface of said housing; and

at least one socket formed in a second surface of said housing, said socket comprising a plurality of contact elements electrically coupled to said plurality of spring-loaded contact pads, and said socket adapted to receive at least a portion of a device connector of said peripheral device, wherein said plurality of contact elements are configured to be springingly biased against said portion of said device connector inserted into said socket, and

wherein each of said plurality of contact elements are configured to electrically couple one of a plurality of electrical elements in said portion of said device connector to one of said plurality of spring-loaded contact pads, and wherein said housing is configured to have a size and shape such that a combined dimensional footprint of said peripheral device and said housing and a dimensional footprint of said peripheral device alone are substantially the same when said portion of said device connector is inserted into said socket.

16. A storage system, comprising:

a mass storage device having a disc drive form factor, the mass storage device having a disc drive connector for providing an external electrical interface to the storage device when connecting to an external computing environment;

a printed circuit board (PCB), separate from the storage device, that forms part of a computing environment external to the mass storage device, the PCB having a plurality of electrical connection pads for electrically interfacing with the mass storage device;

a connector adapter attached to said disc drive connector, the connector adapter comprising a housing, at least one socket formed on a first surface of said housing for receiving and mating with said disc drive connector, and a plurality of contact pads formed on a second surface of said housing;

## 14

wherein said mass storage device is removably attached to said PCB in a flat surface mounted arrangement, such that said plurality of contact pads on the connector adapter is biased against said plurality of PCB electrical connection pads to electrically interconnect the mass storage device and the PCB.

17. The storage system of claim 16, wherein: said plurality of contact pads comprise a plurality of spring-loaded contact pads extending from the second surface of said housing; and said socket comprises a plurality of contact elements electrically coupled to said plurality of spring-loaded contact pads, and said socket adapted to receive at least a portion of the drive connector, wherein said plurality of contact elements is configured to be springingly biased against the drive connector when inserted into said socket, and wherein each of said plurality of contact elements are configured to electrically couple one of a plurality of electrical elements in said drive connector to one of said plurality of spring-loaded contact pads, and wherein the housing is configured to have a size and shape such that a combined dimensional footprint of said mass storage device and said housing and a dimensional footprint of said mass storage device alone are substantially the same when said standardized connector is inserted into said socket.

18. A system for electrically interconnecting at least one storage device having a first dimensional footprint to an external computing environment, comprising:

an external printed circuit board (PCB) separate from the storage device, the external PCB having one or more PCB electrical connection elements;

a storage device PCB connected to a bottom surface of the storage device and having at least one storage device connector portion; and

a connector attached to said storage device connector portion, the connector comprising a housing, at least one socket formed on a first surface of said housing for mating with one of said storage device PCB connector portion and said PCB electrical connection elements, and a plurality of spring-loaded contact pads formed on a second surface of said housing,

wherein said plurality of spring-loaded contact pads are springingly biased against an other of said storage device PCB connector portion and said PCB electrical connection elements when the storage device is deposited on the external PCB such that a solderless connection is formed between the storage device connection portion and the external PCB, and said housing is configured to have a size and shape such that a combined dimensional footprint of said storage device and said connector is substantially the same as said first dimensional footprint when said connector is attached to said storage device connector portion.

19. A solderless connection mechanism for electrically connecting an electronic peripheral device to a printed circuit board, the connection mechanism comprising:

a plurality of electrically conductive contact pads printed on a surface of the printed circuit board;

a first connector including a plurality of spring-loaded contact pads associated with the electronic peripheral device for electrically coupling with said plurality of electrically conductive contact pads on the printed circuit board such that the electronic peripheral device is electrically connected to the printed circuit board; and

an adapter, wherein said first connector is provided on said adapter, said adapter further comprising a second connector for mating with a device connector on said electronic peripheral device.



**15**

**20.** The solderless connection mechanism of claim **19**, wherein said adapter further comprises at least two guide posts configured for insertion into at least two corresponding apertures in the printed circuit board for registering said plurality of spring-loaded contact pads of said first connector in proper orientation relative to said plurality of electrically conductive contact pads. 5

\* \* \* \* \*

**16**